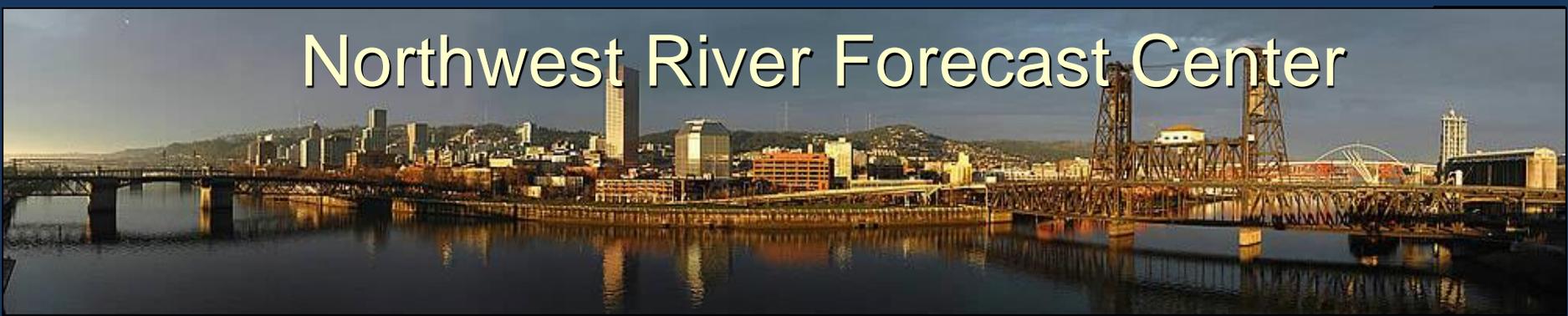


Northwest River Forecast Center



Ensemble Streamflow Prediction (ESP) Water Supply Forecast Procedure

Telephone Conference : 1-888-819-6075
Pass Code : 32317

Presentation available after brief at:

www.nwrfc.noaa.gov/presentations/presentations.cgi

Kevin Berghoff
Senior Hydrologist

NOAA/NWS/Northwest River Forecast Center
Portland, OR





Presentation Outline



- Forecast Model and Operation Description
- Seasonal Volumetric Forecasts Using ESP
- Web Services and Products



NWRFC Forecast Model



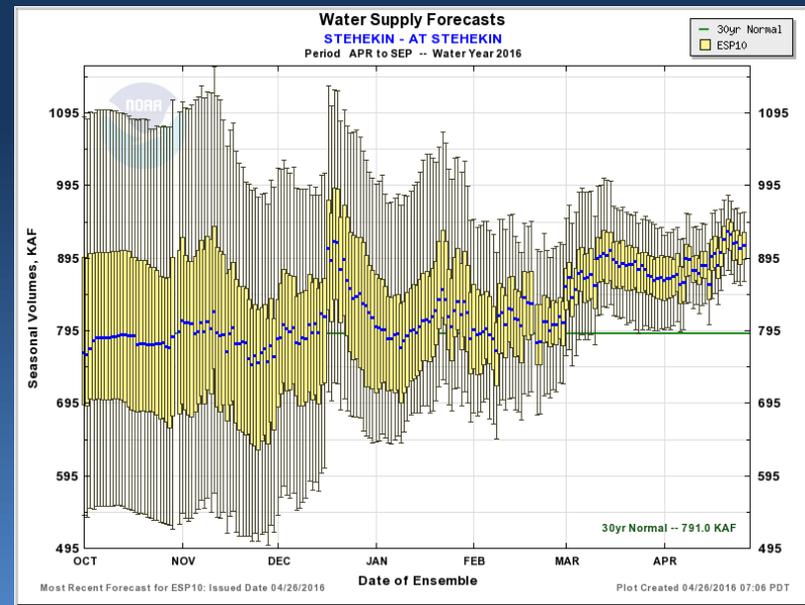
Community Hydrologic Prediction System (CHPS)

- Forced by *Precipitation and Temperature* (Obs and Fcst)
- Short and Long-term Forecast Capability

10 Day Deterministic River Forecast



Seasonal Probabilistic Forecast (ESP)





Conceptual Hydrologic Model

Multiple Uses – Same Model

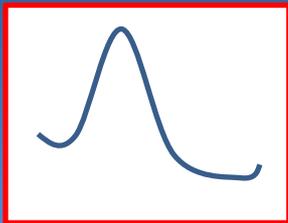


Deterministic
Model

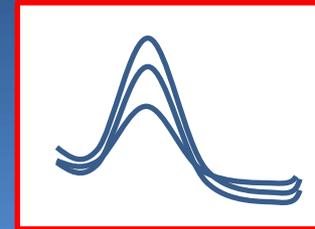
Ensemble
Model



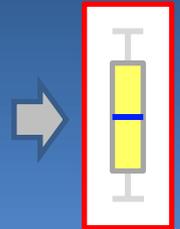
10 Day River
Forecast



ESP
Forecast
Ensembles



ESP WS
Forecast





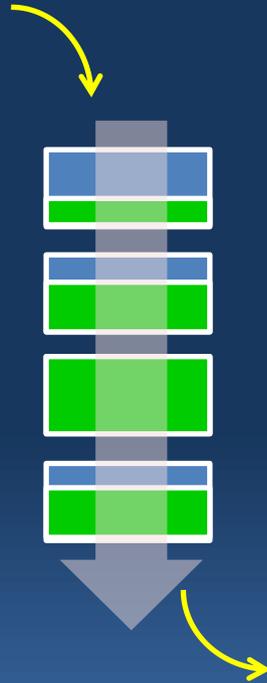
Understanding the CHPS Forecast Model

Input Forcings: *Obs & Fcst*

- *Precipitation*
- *Temperature*

Model Operations

- *SNOW17*
- *SAC-SMA*
- *Consumptive Use*
- *Regulation*
- *Routing*



Model States

- *Snow Water Equivalent*
- *Snow Cover*
- *Soil Moisture*
- *River/Reservoir Levels*

Deterministic Output Hydrograph

- *River Flow*
- *River Stage*
- *Pool Elevation*

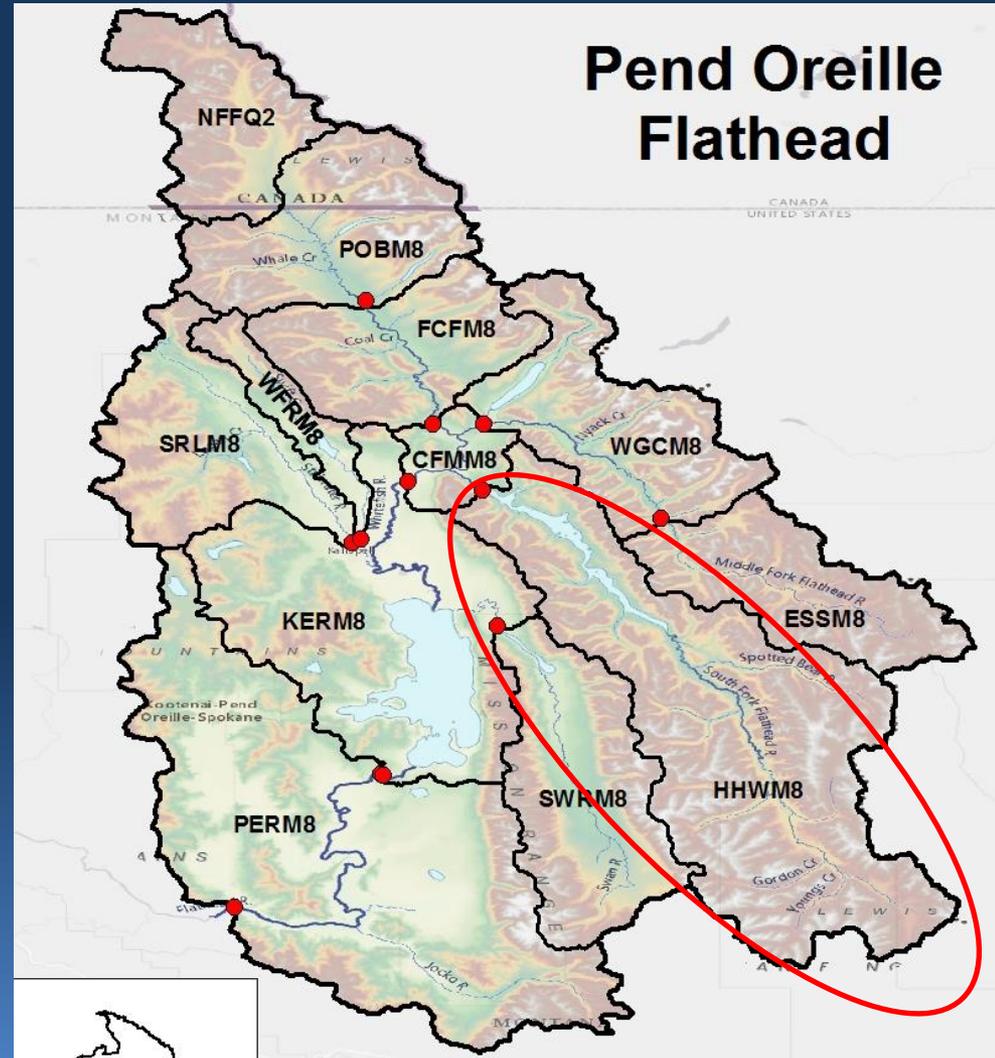
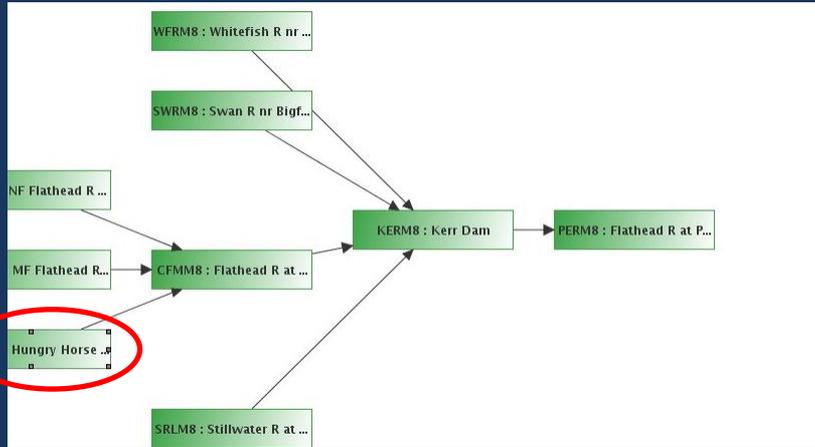
Deterministic Mode

- ONE forcings set and ONE output



CHPS Configuration for Flathead River Basin

SF Flathead River - Hungry Horse Reservoir



Model Construction for **HHWM8**

- Upper Elevation Zone 6500'-8520'
- Lower Elevation Zone 3540'-6500'

Model Operations Applied at Each Zone:

- Computed Mean Areal Forcings
- Rain-Snow Operation
- Snow Model (SNOW-17)
- Soil Moisture Model (SAC-SMA)

Runoff Converted to Flow and Routed

- Unit Hydrograph
- Reservoir Model (SSARRESV)

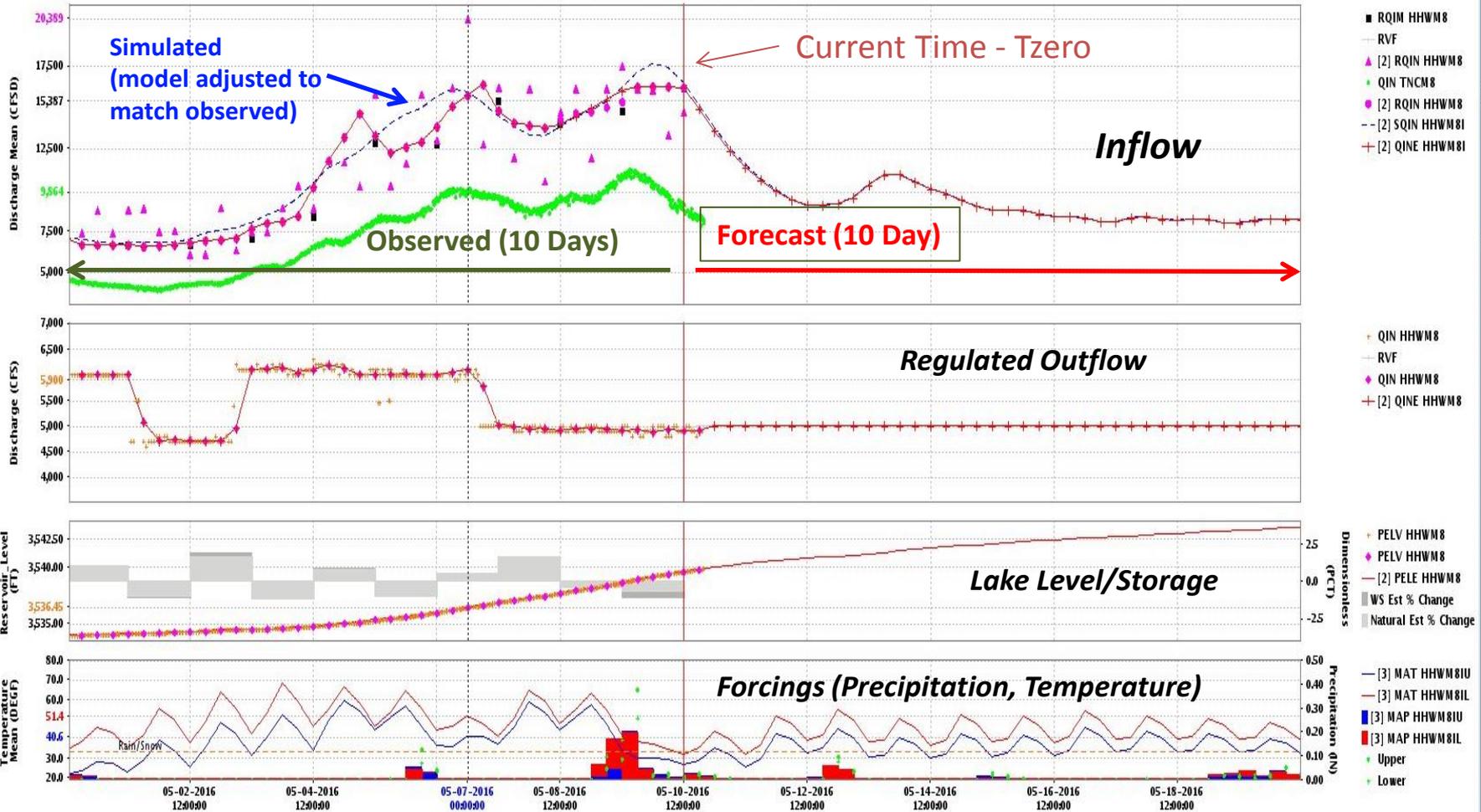


Community Hydrologic Prediction System (CHPS)

Interactive Forecast Display (Forecast Plot)



HHWM8 - Hungry Horse Dam - IN-OUT



External: [1] 05-10-2016 12:00:00 GMT HHWM8_Forecast; [2] HHWM8 : Hungry Horse... 05-10-2016 12:00:00 GMT Local Forcing_Processing; [3] Process Forcings 05-10-2016 12:00:00 GMT Current

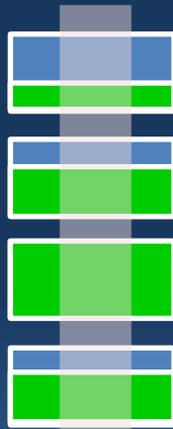
← Observed | Forecast →



Ensemble Streamflow Prediction (ESP)

Input Forcings: Ensemble of Weather Years (1948-2015)

- *Precipitation*
- *Temperature*

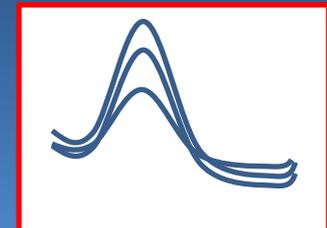


Combined with Current Model States

- *Snow Water Equivalent*
- *Snow Cover*
- *Soil Moisture*
- *River/Reservoir Levels*

Ensemble of Output Hydrographs (67 Traces)

- *River Flow*
- *River Stage*
- *Pool Elevation*

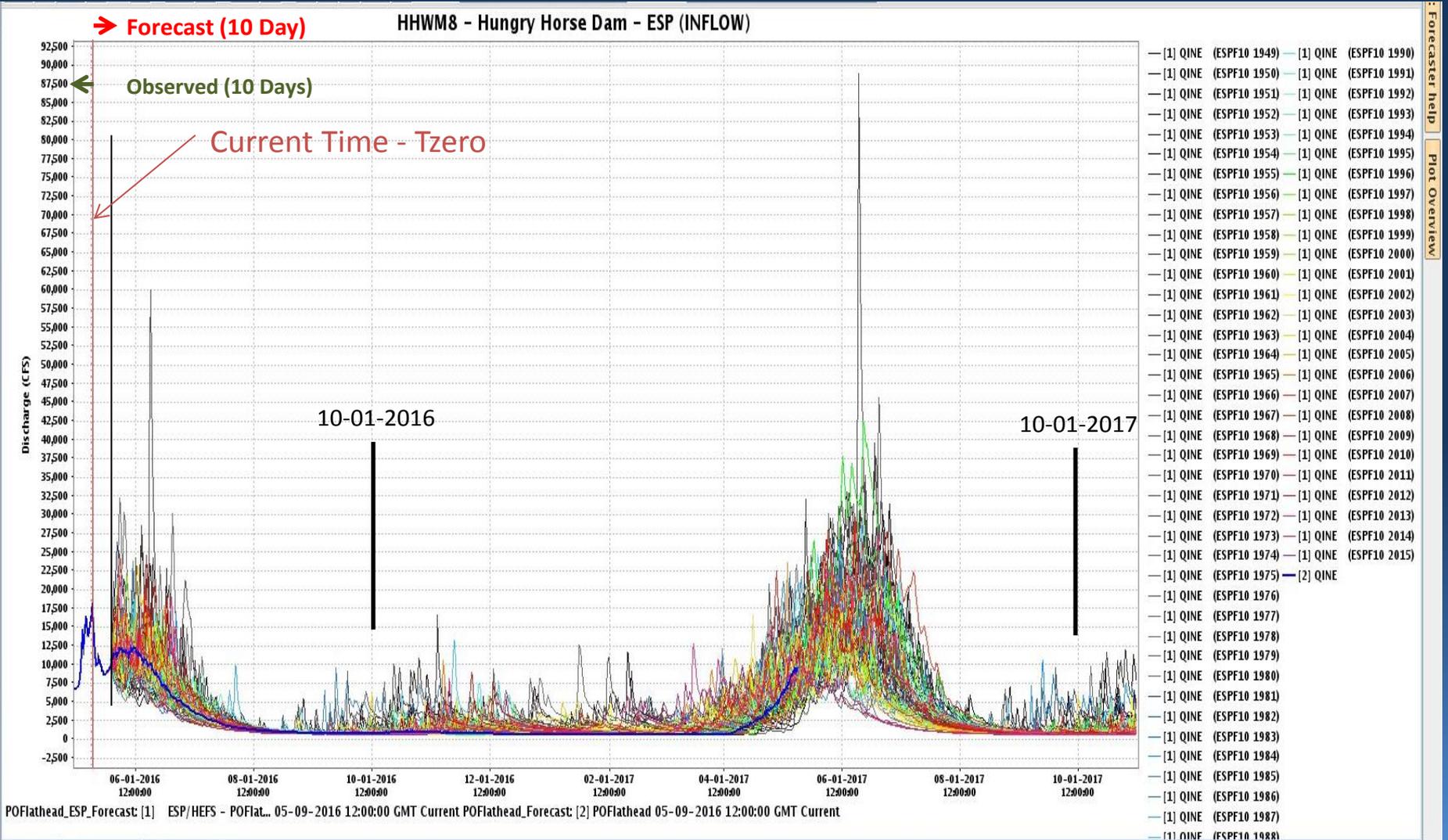


Ensemble Mode

- MANY forcings and ONE output for EACH
- EACH assumed to be EQUALLY LIKELY
- DISTRIBUTION represents UNCERTAINTY



Ensemble of Inflow Hydrographs



Forecast help Plot Overview

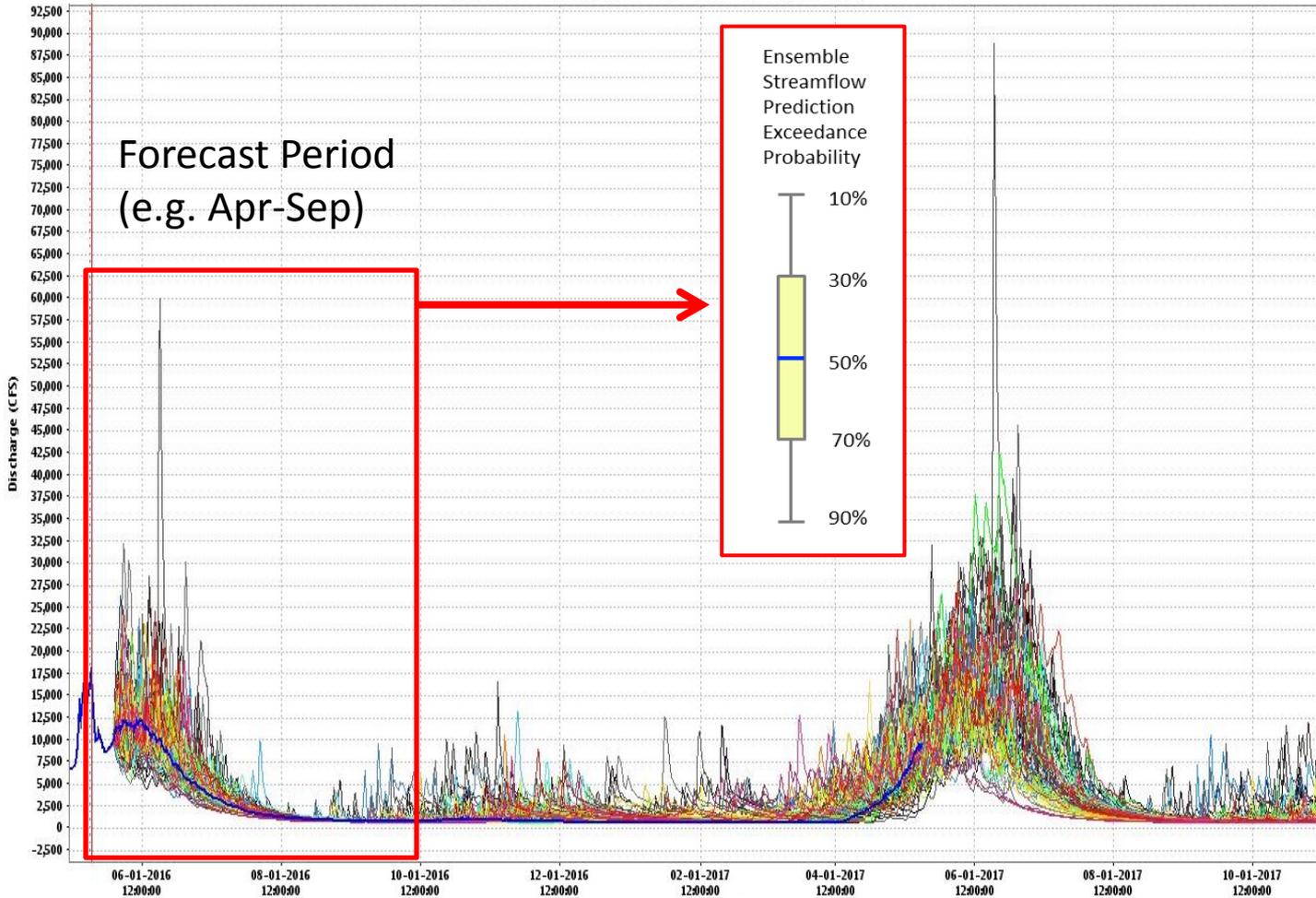


Statistical Summary of ESP Water Supply

Ensemble Traces Conveyed as Exceedance Probabilities



HHWM8 - Hungry Horse Dam - ESP (INFLOW)



- [1] QINE (ESPF10 1949)
- [1] QINE (ESPF10 1950)
- [1] QINE (ESPF10 1951)
- [1] QINE (ESPF10 1952)
- [1] QINE (ESPF10 1953)
- [1] QINE (ESPF10 1954)
- [1] QINE (ESPF10 1955)
- [1] QINE (ESPF10 1956)
- [1] QINE (ESPF10 1957)
- [1] QINE (ESPF10 1958)
- [1] QINE (ESPF10 1959)
- [1] QINE (ESPF10 1960)
- [1] QINE (ESPF10 1961)
- [1] QINE (ESPF10 1962)
- [1] QINE (ESPF10 1963)
- [1] QINE (ESPF10 1964)
- [1] QINE (ESPF10 1965)
- [1] QINE (ESPF10 1966)
- [1] QINE (ESPF10 1967)
- [1] QINE (ESPF10 1968)
- [1] QINE (ESPF10 1969)
- [1] QINE (ESPF10 1970)
- [1] QINE (ESPF10 1971)
- [1] QINE (ESPF10 1972)
- [1] QINE (ESPF10 1973)
- [1] QINE (ESPF10 1974)
- [1] QINE (ESPF10 1975)
- [1] QINE (ESPF10 1976)
- [1] QINE (ESPF10 1977)
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- [1] QINE (ESPF10 1979)
- [1] QINE (ESPF10 1980)
- [1] QINE (ESPF10 1981)
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- [1] QINE (ESPF10 1983)
- [1] QINE (ESPF10 1984)
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- [1] QINE (ESPF10 2003)
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- [1] QINE (ESPF10 2006)
- [1] QINE (ESPF10 2007)
- [1] QINE (ESPF10 2008)
- [1] QINE (ESPF10 2009)
- [1] QINE (ESPF10 2010)
- [1] QINE (ESPF10 2011)
- [1] QINE (ESPF10 2012)
- [1] QINE (ESPF10 2013)
- [1] QINE (ESPF10 2014)
- [1] QINE (ESPF10 2015)
- [2] QINE

POFlathead_ESP_Forecast: [1] ESP/HEFS - POFlat... 05-09-2016 12:00:00 GMT Current POFlathead_Forecast: [2] POFlathead 05-09-2016 12:00:00 GMT Current



Statistical Summary of ESP Water Supply

Seasonal Exceedance Probability Forecasts displayed for entire water year



SF FLATHEAD - HUNGRY HORSE DAM (HHWM8) Forecasts for Water Year 2016

Official Forecast

10 days QPF: Ensemble: 2016-05-10 Issued: 2016-05-10

Forecast Period	Forecasts Are in KAF				30 Year Average (1981-2010)
	90 %	50 %	% Average	10 %	
APR-SEP	1708	1862	94	2129	1988
APR-JUL	1613	1745	93	2021	1871
APR-AUG	1665	1814	94	2087	1936
JAN-SEP	1988	2142	97	2409	2215
JAN-JUL	1893	2025	97	2301	2098
OCT-SEP	2133	2287	93	2554	2447

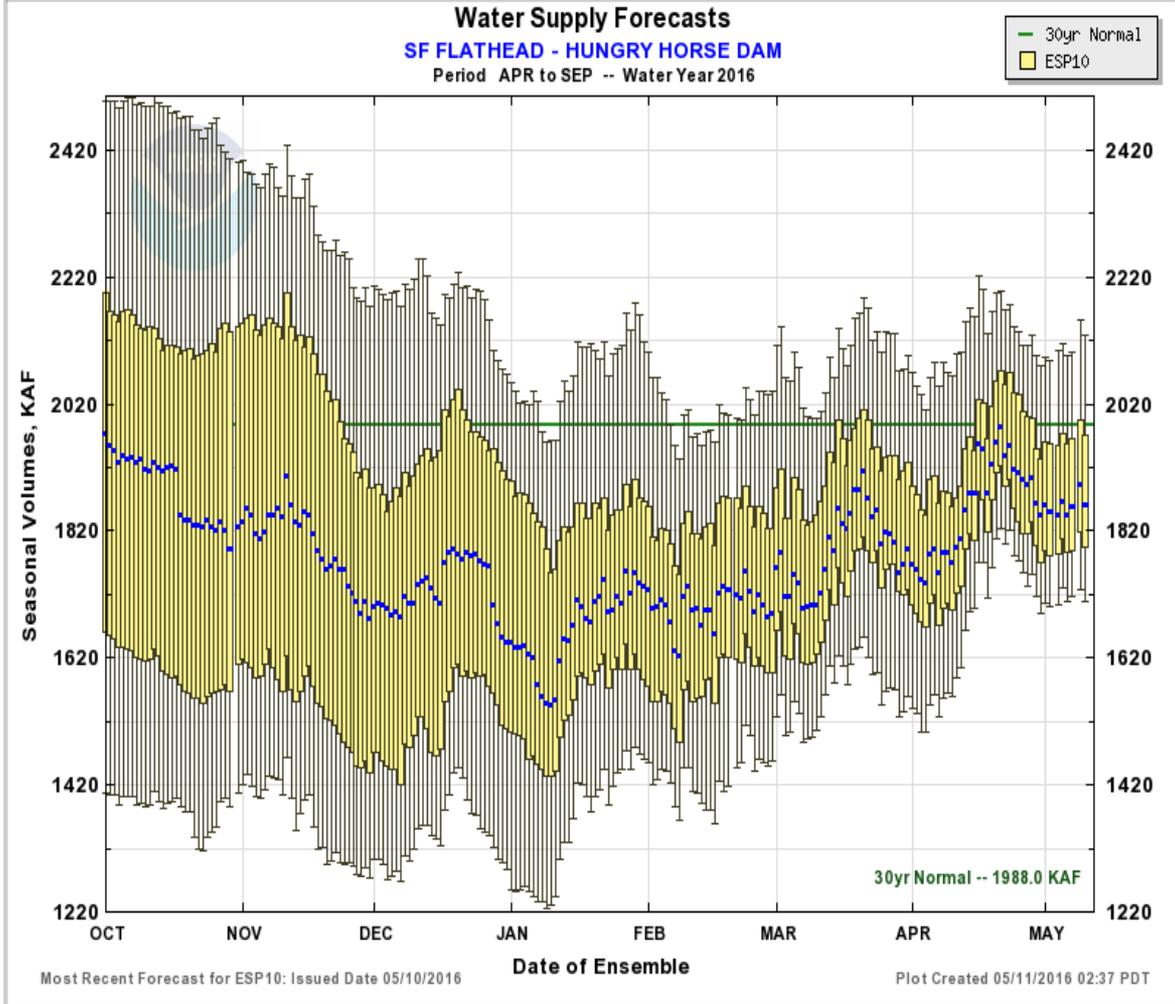
5 days QPF: Ensemble: 2016-05-10 Issued: 2016-05-10

APR-SEP	1745	1899	96	2146	1988
APR-JUL	1660	1774	95	2038	1871
APR-AUG	1707	1844	95	2104	1936
JAN-SEP	2025	2179	98	2426	2215
JAN-JUL	1940	2054	98	2318	2098
OCT-SEP	2170	2323	95	2571	2447

0 days QPF: Ensemble: 2016-05-10 Issued: 2016-05-10

APR-SEP	1773	1938	97	2169	1988
APR-JUL	1678	1816	97	2064	1871
APR-AUG	1724	1885	97	2129	1936
JAN-SEP	2053	2218	100	2449	2215
JAN-JUL	1958	2096	100	2344	2098
OCT-SEP	2198	2362	97	2594	2447

Move the mouse over the desired "Forecast Period" to display a graph.



Max Scale
 Scale To Data
 Scale To Last 45 Days



Flavors of ESP Forecasts



- **Number of Days of Deterministic Precip/Temp (10,5,0 Days)**
 - Short-term weather forecast included for first 10, 5, or 0 days
 - ESP10 (NWS Official Water Supply Forecast)
 - ESP5 (used by COE to regulate Columbia River system)
 - ESP0 (no short-term weather forecast, historic forcings only)
- **Flow Configuration**
 - Unadjusted (observed in the river)
 - deterministic outflow below a project
 - Observed and forecast flow at a point
 - Adjusted
 - *ESP water supply* (adjusted for upstream storage, no routing)
 - *ESP natural water supply* (adjusted for ALL modeled upstream alterations; includes routing)
 - Storage
 - Consumptive Use
 - Channel Loss/Gain
 - Channel Routing

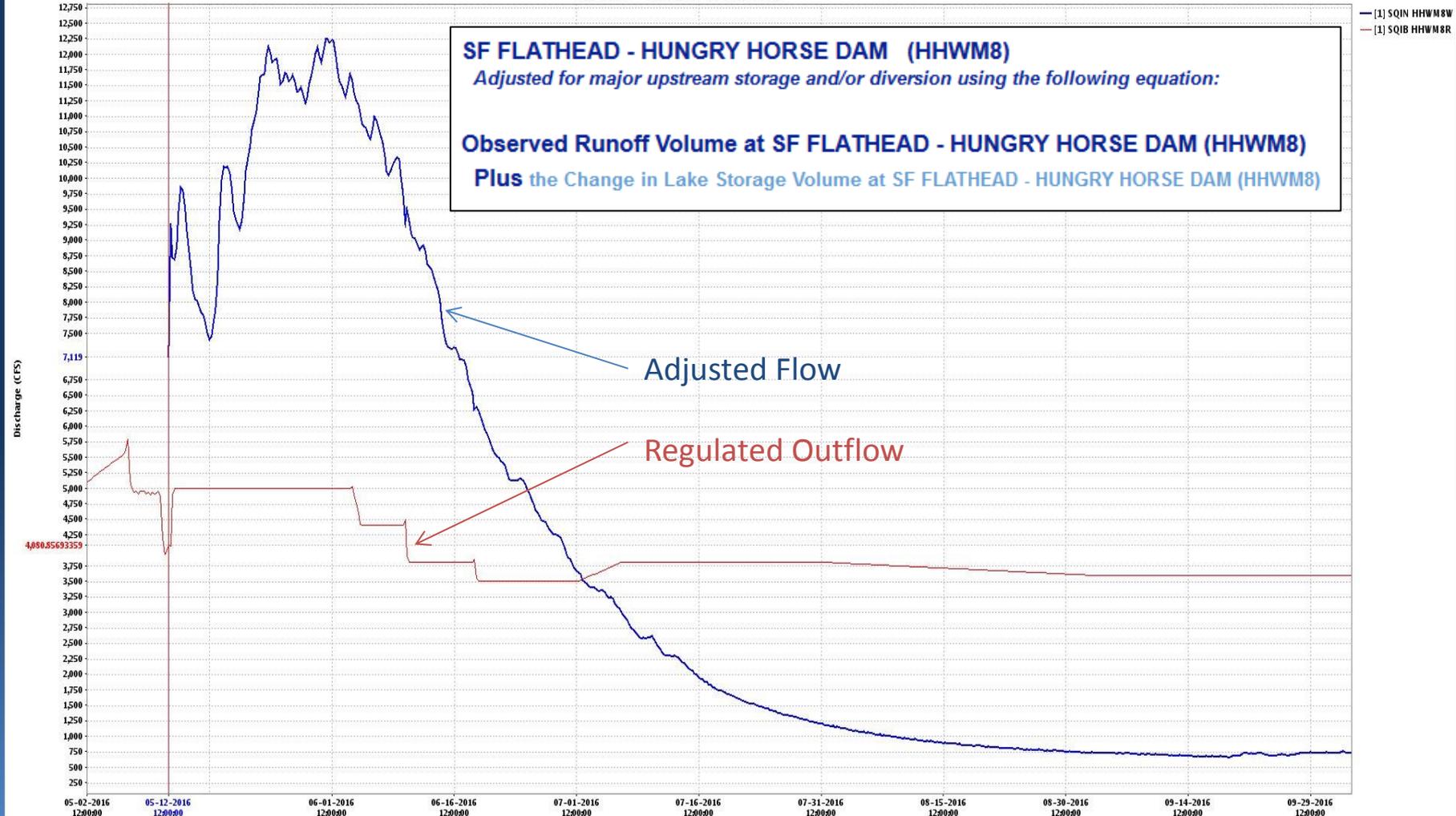


ESP Water Supply Forecast



24 [Tools] Sample <Select a sample function> Functions <Select a statistical function>

HHWM8 - Hungry Horse Dam



POFlathead.Forecast: [1] POFlathead 05-12-2016 12:00:00 GMT Current

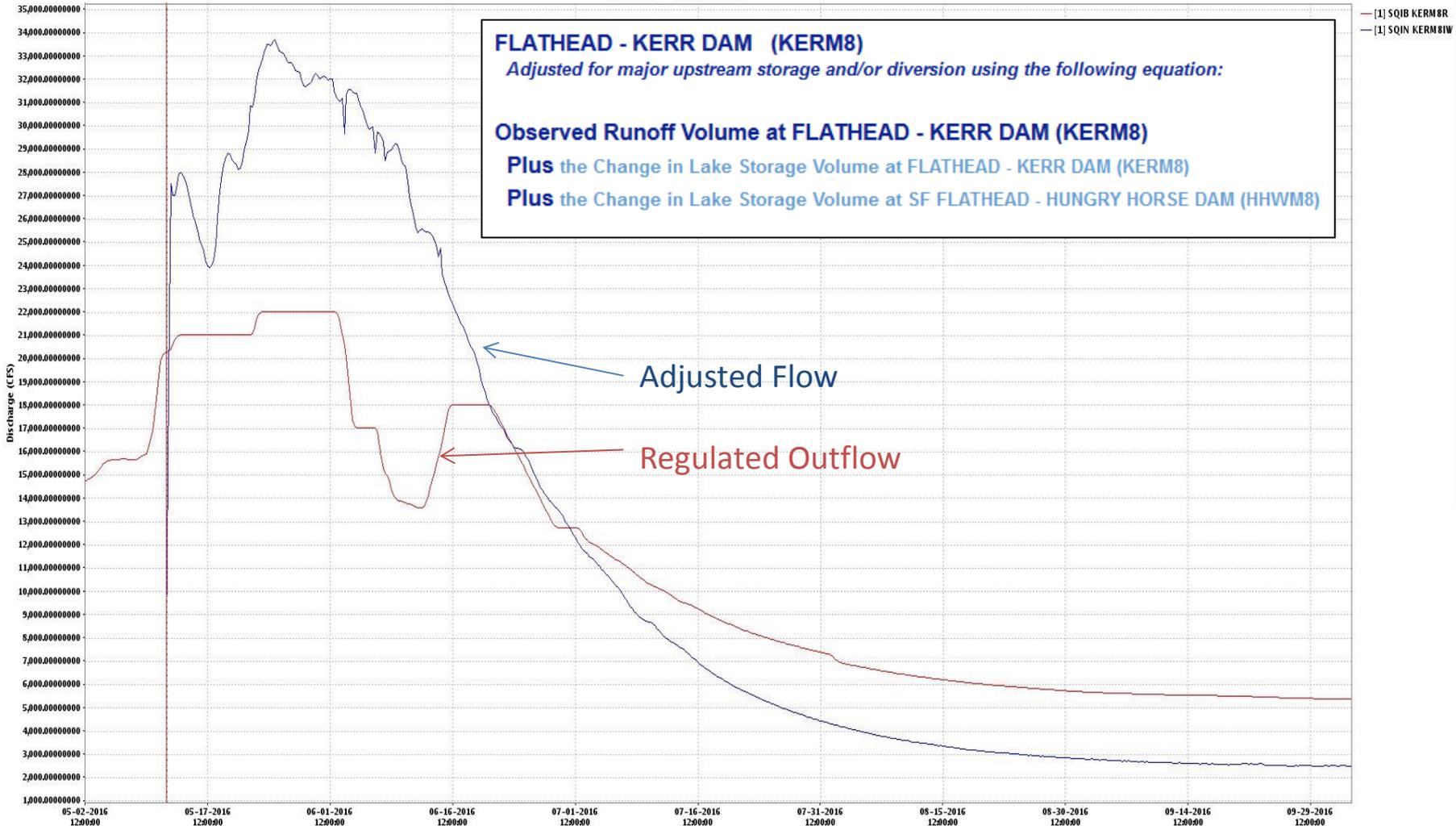


ESP Water Supply Forecast



24 [Icons] Sample <Select a sample function> Functions <Select a statistical function>

KERM8 - Kerr Dam



POFlathead_Forecast: [1] POFlathead 05-12-2016 12:00:00 GMT Current

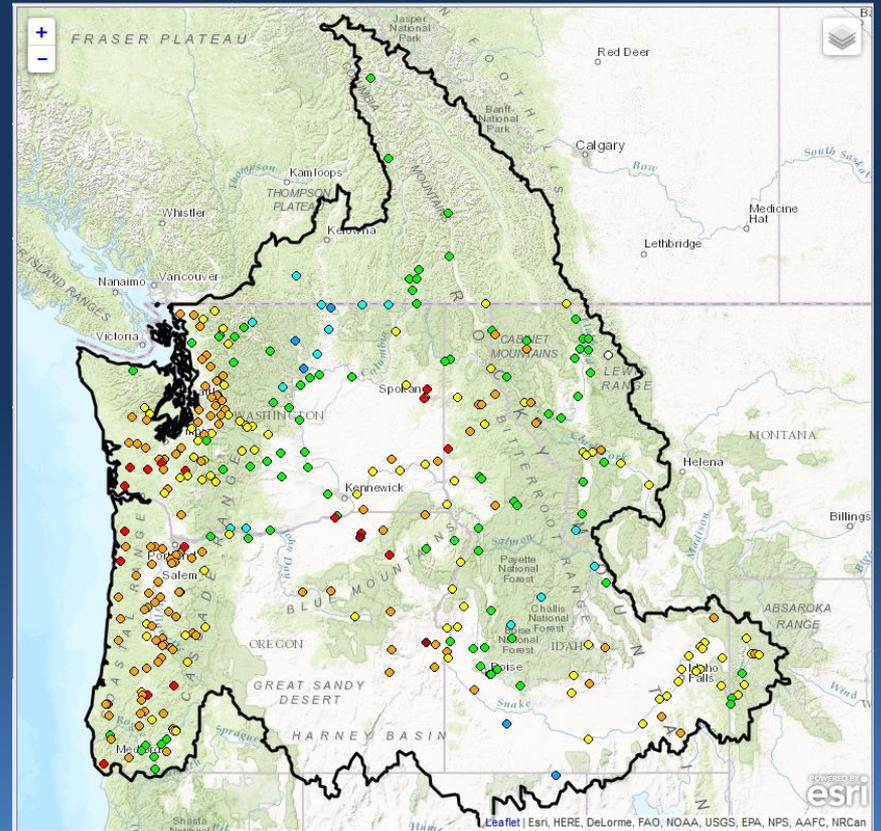
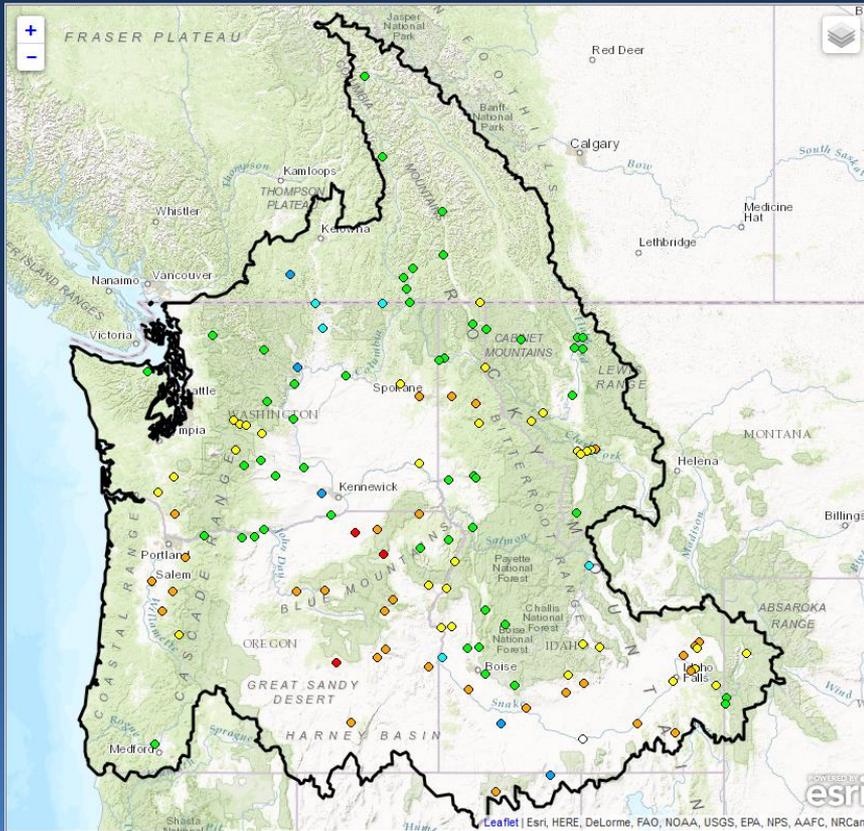


ESP Forecast Point Network



ESP Legacy WSF – 126 Locations

ESP Natural WSF – 330 locations





1981 – 2010 Seasonal Volume Normals – KAF

ESP WSF vs ESP Natural WSF



SF Flathead at Hungry Horse Dam

	Apr - Sep	Apr - Jul	Jan - Jul	Oct - Sep
ESP WSF	1988	1871	2098	2447
ESP Natural WSF	1988	1867	2098	2459

Columbia R at the Dalles Dam

	Apr - Sep	Apr - Jul	Jan - Jul	Oct - Sep
ESP WSF	92704	79855	101368	130518
ESP Natural WSF	96012	82019	102438	132349



ESP: Strengths and Challenges

- **Strengths**

- Provides probabilistic information for risk planning
- Issued Daily, 365 days a year
- Flexible (multiple flavors, configurations, forecast periods)
- Includes weather forecast (out to 10 days)
- Full Integration with NWRFC short term river models
- Evolving operational procedure (improvements expected)

- **Challenges**

- Uncertainty due to observed forcings and model states not accounted for (model spread is not as wide as it should be)
- Forecasts can be subject to day to day instability
- Complicated (hard to troubleshoot, challenge to articulate)



ESP WSF Compared to Statistical Water Supply



- **In Common**

- Calibrated against streamflow/runoff
- Forecasts presented as statistical summary
- Forecasts compared to 30yr Average Runoff (1981 – 2010)

- **Not in Common**

- Model Design (continuous conceptual vs statistical regression)
- ESP issued daily; SWS monthly
- ESP uses observed and future forcings (SWS uses obs only)
- ESP is part of a larger modeling system; SWS is specific to task



Additional Products and Services

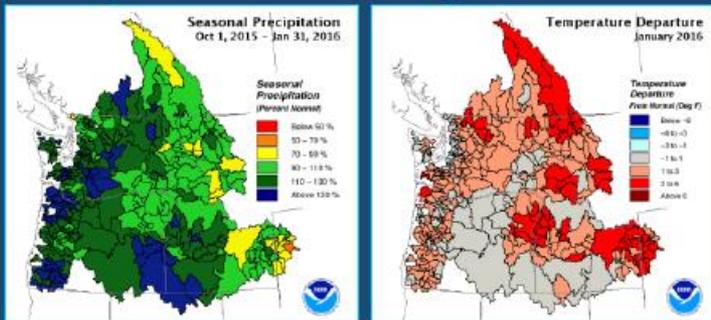


Regional Conditions / Historical Observations
Rankings / Data / Contextual Information

Live: Water Supply Webinars

Next Briefing: 2017

Monthly/Seasonal Conditions Precipitation & Temperature



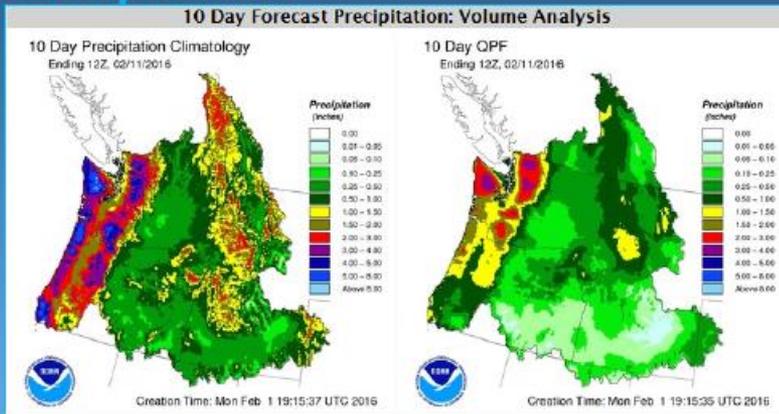
Data Downloads: Forecasts, Forcings, Runoff



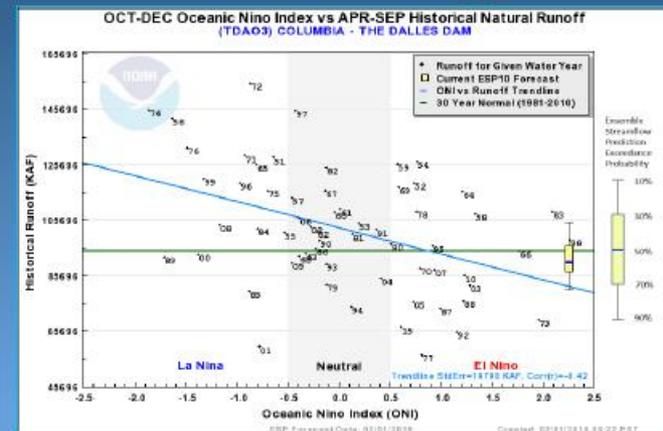
Northwest River Forecast Center
Data Download

Ensembles, Forcings, Runoff

10 Day Forecast Precipitation



NEW: ENSO vs Runoff Plots



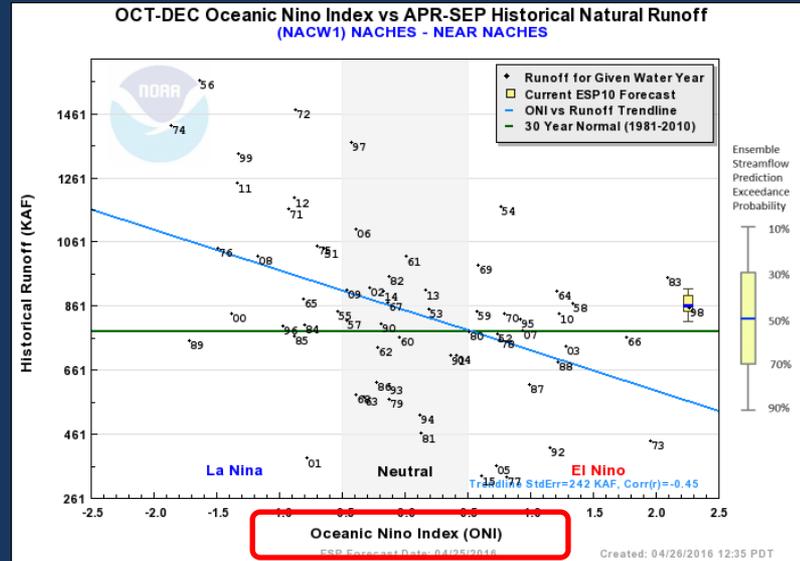


NWRFC Summer Web Enhancements



ENSO – Runoff Plots

- Phase 1 (WY 2016):
 - OCT-DEC ONI vs Runoff
- Phase 2 (WY 2017):
 - User Selection for Climate Index and Period



Data Download Service

- Late WY 2015:
 - ESP Ensembles
 - Model Forcings
 - Runoff
- Q3 of WY 2016:
 - Gridded Forcings (netcdf format)



Questions?



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W-ptr.Webmaster@noaa.gov
(503)326-7291

